Conservation Biology

Registered Report

Efficacy-based and normative interventions for facilitating the diffusion of conservation behavior through social networks

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Abstract: Research suggests that encouraging motivated residents to reach out to others in their social network is an effective strategy for increasing the scale and speed of conservation action adoption. However, little is known about how to effectively encourage large numbers of residents to reach out to others about conservation causes. We examined the influence of normative and efficacy-based messaging at motivating residents to engage in and to encourage others to participate in native plant gardening in their community. To do so, we conducted a field experiment with messages on mailings and tracked native plant vouchers used. Efficacy messages tended to be more effective than normative messages at increasing residents' willingness to reach out to others to encourage conservation action, as indicated by a several percentage point increase in native plant voucher use by residents' friends and neighbors. Messages sometimes had different impacts on residents based on past behaviors and perceptions related to native plant gardening. Among these subgroups, efficacy and combined efficacy and norm messages most effectively encouraged individual and collective actions, as indicated by increased voucher usage. Our findings suggest that interventions that build residents' efficacy for engaging in a conservation behavior and for reaching out to others may be a promising path forward for outreach. However, given our results were significant at a false discovery rate cutoff of 0.25 but not 0.05, more experimental trials are needed to determine the robustness of these trends.

Keywords: conservation behavior, conservation psychology, efficacy, framing, messaging, norms

Intervenciones Normativas y Basadas en la Eficiencia para Facilitar la Difusión del Comportamiento de Conservación por Medio de las Redes Sociales

Resumen: Las investigaciones sugieren que alentar a los residentes motivados para que se comuniquen con otros en sus redes sociales es una estrategia efectiva para incrementar la escala y velocidad de la adopción de las acciones de conservación. Sin embargo, se sabe poco sobre cómo alentar de manera efectiva a un gran número de residentes para que hablen con otros sobre las causas de la conservación. Examinamos la influencia de la mensajería normativa y basada en la eficiencia sobre la motivación de los residentes para ellos mismos participar y alentar a otros a participar en la jardinería de plantas nativas dentro de su comunidad. Para lograr esto, realizamos un experimento de campo con mensajes en los envíos y rastreo de los vales usados para plantas nativas. Los mensajes de eficiencia tendieron a ser más efectivos que los mensajes normativos para incrementar la voluntad de los residentes para alentar a otros a tomar acciones de conservación, como lo indicó el incremento de varios puntos porcentuales en el uso de vales para plantas nativas de los amigos y vecinos de los residentes. Los mensajes a veces tuvieron un impacto diferente sobre los residentes con base en los comportamientos pasados y las percepciones relacionadas con la jardinería de plantas nativas. Entre estos subgrupos, la eficiencia, la eficiencia combinada y

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los mensajes normativos fueron los factores que alentaron de manera más efectiva las acciones individuales y colectivas, como lo indicó el incremento en el uso de vales. Nuestros hallazgos sugieren que las intervenciones que construyen la eficiencia de los residentes para participar en el comportamiento de conservación y para comunicarse con otros sobre éstas puede ser un camino prometedor para la divulgación. Sin embargo, ya que nuestros resultados fueron significativos a una tasa límite de descubrimientos falsos de 0.25 y no 0.05, se requieren más pruebas experimentales para determinar la fortaleza de estas tendencias.

Palabras Clave: comportamiento de conservación, eficiencia, encuadre, mensajería, normas, psicología de la conservación

Introduction

Achieving conservation outcomes often requires motivating widespread human behavior change (Amel et al., 2017; Schultz, 2011). Encouraging a large number of people to quickly change their behavior can expand wildlife habitat or reduce habitat destruction (Belaire et al., 2014; Ma et al., 2012; Paker et al., 2014), prevent or slow the spread of invasive species (McKiernan, 2018; Niemiec et al., 2016), and prevent the overharvesting of native species (Cooney et al., 2017). To enhance the scale and speed of conservation behavior change, social scientists have demonstrated the value of integrating the "block leader approach" into outreach programs (Abrahamse & Steg, 2013; Burn, 1991; Niemiec et al., 2019). The block leader approach (also referred to as "the captain model" and "relational organizing") involves enlisting motivated community volunteers to help spread a conservation behavior throughout their social network. Specifically, this approach encourages individuals engaging in the conservation behavior themselves to also engage in diffusion behaviors, which we define as actions that facilitate the uptake of a new behavior by others in one's community. Diffusion behaviors include sharing information with, helping, or providing persuasive arguments to others about a desired behavior (Jones & Niemiec, 2020).

The block leader approach challenges the traditional knowledge-transfer conservation outreach model, which focuses primarily on experts sharing information with community members to encourage them to engage in individual conservation behaviors (Amel et al., 2017; Kollmuss & Agyeman, 2002; Ma et al., 2012). Results of field experiments and meta-analyses suggest the block leader approach is highly effective at inspiring widespread community action for environmental causes, such as recycling (Abrahamse & Steg, 2013; Burn, 1991). This approach holds promise for a diversity of behaviors that aid biodiversity conservation, such as invasive species management and native plant landscaping (Niemiec et al., 2019). The block leader approach may be effective because it increases the chance of information about a behavior getting to new, less motivated audiences (Abrahamse & Steg, 2013) because people who may not normally seek this information may hear about it from friends, family, or neighbors who are acting as block leaders. This may be particularly important for conservation organizations that are frequently faced with the problem of preaching to the choir when their programs are attended by already motivated individuals (Ma et al., 2012). Furthermore, people are more likely to comply with requests from individuals they know or perceive to be similar to themselves (Burger et al., 2004; Cialdini, 2001); thus, motivated individuals reaching out to others in their social network may increase the probability that people act on new information they receive (Abrahamse & Steg, 2013). In addition, the block leader approach can lead to sustained behavior change by helping to establish and reinforce new social norms within a social network (McKiernan 2018). Social norms are the social rules that define acceptable behaviors; social norms are enforced directly by group members or indirectly by perceptions of group member expectations (Cialdini & Trost, 1998). New norms can be established by community members sharing information and applying social pressure to others about a new behavior and can help promote sustained behavior change (McKeirnan, 2017).

A growing body of literature demonstrates the value of the block leader approach for promoting conservation causes, but a key challenge to its implementation is scaling it up (Buijs et al., 2019). Scaling up requires encouraging existing block leaders to reach out to more people in their social network (i.e., engage in more diffusion behaviors). Scaling up also requires recruiting more block leaders (i.e., encouraging additional individuals to engage in diffusion behavior beyond those who are easily recruited as community leaders) so that additional social networks are reached. Scaling up the block leader approach could increase the number of individuals from diverse social networks that quickly adopt a conservation behavior, which can help achieve conservation objectives across human-dominated landscapes.

Scaling up the block leader approach may be difficult because many individuals who engage in conservation behavior rarely reach out to others they know to discuss environmental topics or behavior change (Geiger & Swim, 2016). For example, despite the high level of support for climate-change mitigation, only one-quarter of the U.S. public regularly discusses climate change with others (Leiserowitz et al., 2015). Similarly, individuals engaging in biodiversity conservation behaviors rarely reach out to their friends, family, or neighbors to spread information about their behavior (Niemiec et al., 2019).

A small but growing body of research suggests that people's unwillingness to recruit others in their social network may be a result of unique social-psychological barriers that individuals face when reaching out to others (Amel et al., 2017; Geiger & Swim, 2016; Geiger et al., 2017). One barrier may be a lack of self-efficacy and response efficacy in approaching others. Self-efficacy refers to the belief in one's ability to engage in a task effectively; response efficacy refers to the belief that one's action will achieve a desired result (Kusmanoff et al., 2020). There are correlations between people's perceived self-efficacy in reaching out to others and their frequency of discussion of environmental topics (Swim et al., 2014; Swim & Fraser, 2014). Furthermore, one's perceived response efficacy related to influencing others is correlated with frequency of reaching out to others about environmental causes (Lubell et al., 2007; Niemiec et al., 2016). Bolstering self-efficacy by providing an easy-to-remember "explanatory chain" about the causes and consequences of climate change increases willingness to discuss climate change (Geiger et al., 2017). Together, this research suggests that interventions that bolster self- and response efficacy with regard to reaching out to others may increase the number of individuals diffusing conservation behaviors.

A second barrier to engaging in diffusion behavior may be normative perceptions that others are not interested in the conservation issue, are not engaging in the behavior, or are not willing to encourage others to act (Geiger & Swim, 2016; Kusmanoff et al., 2020; Niemiec et al., 2016; Niemiec et al., 2019). Geiger and Swim (2016), for example, documented a "spiral of silence," in which individuals refrain from reaching out to others about climate change because they inaccurately believe others do not care about climate change. They found that correcting these inaccurate perceptions about others' beliefs (i.e., second-order normative beliefs [Jachimowicz et al., 2018]) can enhance people's willingness to talk to others about climate change. Niemiec et al. (2019) found that normative interventions that showcase the number of others working together to control invasive species (i.e., descriptive norms) effectively increased diffusion behaviors. Normative interventions may enhance people's willingness to reach out to others and may be made more effective by emphasizing that others are interested in and supportive of the conservation cause, are engaging in the target behavior, and are engaging in diffusion for the target behavior.

We conducted a field experiment to test the effectiveness of normative and efficacy-based outreach interventions at encouraging individuals to engage in biodiversity conservation on their property and diffuse biodiversity conservation behavior through their social network. We addressed Kidd et al.'s (2019) call for more conservation messaging research that applies established behavioral science theory, uses direct observations of behavior, and tests message effectiveness for diverse target audiences. We used direct indicators of biodiversity conservation behavior to test messaging strategies that draw from efficacy and social norms theory and have the potential to be adapted to a wide range of conservation scenarios. We tested whether these messages have different impacts on 2 different audiences (i.e., an audience highly involved with a conservation issue and a random sample of residents). In doing so, we built on the elaboration likelihood model of persuasion (Petty & Cacioppo, 1986), which suggests that messaging, such as normative interventions, may have a greater impact on individuals who are less personally involved with an issue (Gockeritz et al., 2010; Schultz et al., 2016).

Our field experiment focused on encouraging the diffusion of the conservation behavior of native plant gardening on private property. Native plant gardens can provide critical habitat for wildlife in urban areas and thus can help address declining amphibian, insect, and bird populations (Paker et al., 2014). Planting native species can increase food and shelter available to wildlife, which can in turn achieve landscape-scale benefits for biodiversity (Belaire et al., 2014; Narango et al., 2017). People's decisions to engage in native plant gardening and other actions to benefit biodiversity in residential landscapes can be affected by social norms around lawn care and yard aesthetic (Locke et al., 2018). Thus, altering social norms through a scaled-up block leader approach may be particularly important for this context (van Heezik et al., 2012). Further, encouraging widespread action through the block leader approach is important because the protection of native biodiversity in urban areas may pose a collective action problem, given that there are likely thresholds in how much of a community must replace lawn with native plants for impacts to be seen to birds, insects, and other urban wildlife (Niemiec et al., 2020*a*).

We sent mailings to residents with information about native plant gardening (baseline control) in the form of efficacy-based, normative, or combined efficacy-based and normative messages. Our primary hypotheses were normative, efficacy-based, and combined normative and efficacy-based mailings lead to more indicators of individual and diffusion behavior than the control (information only) mailing (H1); combined normative and efficacy-based mailings lead to more indicators of individual and diffusion behavior than the normative and efficacy-based mailings alone (H2); relative effect size of the normative, efficacy-based, and combined normative and efficacy-based mailings on indicators of individual and diffusion behavior compared with the control is greater for the random sample compared with the highly engaged sample of residents (H3).

Methods

Experiment Sample

Our experiment took place in the primarily suburban landscape in and around the city of Fort Collins, Colorado (U.S.A.) from May to September 2020. Although grass lawns are the most common yard aesthetic in our study area, a survey conducted in 2019 by our research team found that 50% of residents had previously planted a native plant in their yard and 76% were interested in native plant gardening (Appendix S1). Our between-subjects experimental design involved sending out a mailing to 2793 Fort Collins residents. This sample included 793 highly involved residents from an existing mailing list and 2000 randomly sampled residents.

Our sample of highly involved residents was obtained from the City of Fort Collins Natural Areas Program mailing list. The city's Natural Areas Department has a Nature in the City Program that delivers outreach, education, and behavior-change interventions to promote native plant gardening and other urban stewardship behaviors. The Natural Areas list-serv included anyone who attended a City of Fort Collins event related to natural areas, native plant gardening, or outdoor activities and signed up to receive emails about related topics and events. In collaboration with the research team, the City of Fort Collins sent a pre-experiment survey on native plant gardening via email to their list-serv of 9222 people 3 times over 3 weeks in October 2019. The survey measured residents' prior gardening and diffusion behaviors and their related normative and efficacy perceptions (Appendix S2 contains survey instruments and measures). Of the 9222 people who received the survey, 1130 completed it (response rate 12.3%). The majority of respondents had planted native plants before (84.6%) and shared information with others about planting native plants (70.2%), confirming that this was a highly personally involved sample of residents. On the survey, we asked residents to provide their mailing address to be considered for future studies. Of the 1130 who completed the survey, 793 residents lived within 30 miles of Fort Collins in single-family homes and provided their mailing address. These residents were enrolled in the experiment. A power calculation showed that with approximately 200 participants in each of the 4 message conditions (for this subsample of highly involved residents), we could detect an effect size of 0.2 SD for continuous outcomes with an alpha of 0.05 and a 0.2 SD difference in proportions for binary outcomes.

The results of the pre-experimental surveys allowed us to examine how the message condition influenced individuals with different baseline perceptions to determine which efficacy or normative perceptions are most relevant to the interventions' effect on diffusion behavior. Furthermore, the presurveys measured demographic characteristics, which we used as covariates in statistical modeling.

Our random sample of residents enabled us to examine whether the messaging differentially affected residents who may not already be personally involved with native plant gardening. Our random sample was selected from the U.S. Postal Service master address file and included 2000 single-family residences in the Fort Collins Growth Management Area. A survey was sent to this random sample of residents in April 2020 with the same questions about prior behavior and normative and efficacy perceptions that we sent to the highly involved sample. The survey was sent by mail to all residents with a stamped and addressed return envelope. Participants were also given a link to an online version of the survey.

Experimental Design

In May 2020, all 793 residents from the City of Fort Collins Natural Areas Program email list and 1000 of the random sample were mailed a brochure encouraging planting of native plants and 4 vouchers to local plant nurseries. One of the 4 vouchers was a self-voucher with a unique code that participants could use themselves to receive a $10 discount toward the purchase of a native plant, while the remaining 3 friend-and-neighbor vouchers (which also each provided a $10 discount) were designed to be shared with neighbors, friends, and family. Partnering nurseries kept track of each self- and friend-and-neighbor voucher used over the course of the experiment (May–September 2020) and were reimbursed for each voucher. Partnering nurseries ensured only one voucher was used per person when vouchers were redeemed in person. For vouchers redeemed online, the research team checked the names associated with vouchers used and removed from the data set any cases where multiple vouchers were redeemed under the same name. The remaining 1000 residents from the 2000-person random sample were sent the brochure and vouchers in June 2020. We staggered mailing of the brochures to the random sample due to challenges posed by COVID-19; specifically, partnering nurseries did not have enough staff and native plant stock to accommodate the use of all potential vouchers at once in May.

We tracked self-vouchers used to purchase native plants at nurseries as our dependent variable indicating individual native plant gardening behavior. We tracked friend-and-neighbor vouchers used at nurseries as our dependent variable measuring diffusion behavior related to native plant gardening. The code for each neighbor voucher allowed us to track which recipients of self-vouchers provided the voucher to their neighbor, friend, or family member. In the mailings, respondents were also given the option to request a yard sign that they could display about native plant gardening. Because yard signs were a means for passively diffusing information

Table 1. Language used in mailer cards for each of the 4* message conditions (column headings) to encourage native plant gardening on residential properties.

Information-based control	*Norm*	*Efficacy*
"Why plant native plants? Your yard is your outdoor sanctuary. With some careful plant choices, it can also be a haven for native birds, pollinators and other wildlife. Recent science tells us that yards with native plantings provide habitat for more threatened bird species than yards landscaped with typical ornamentals. What's more, growing native plants is a great way to create a beautiful outdoor space while using less water at home." "Did you know that the benefits of planting native plants increase as more people plant them at their homes?" "One of the most important things you can do to help is to talk to your friends and neighbors about why you chose to plant native plants in your yard and encourage them to join you." "Ready to get started? Take these easy steps to build a community of native plant gardening: 1. Plant one or more native plants in a visible area of your yard. Call a participating nursery to place an order, using the enclosed self-voucher to get $10 off. 2. Place a yard sign next to your native plant to share your native plant pride! Email us to request your sign today: wildscapingCSU@gmail.com 3. Encourage your friends and neighbors to plant native plants by sharing why you do. Share the enclosed 'friend and neighbor' vouchers to help them get started."	Information-based control language: "You may think that your neighbors expect you to maintain a grassy lawn, but a recent survey shows that a growing number of Fort Collins residents are planting native plants in their yards. Over 50% have already planted native plants, and 76% are interested in learning more about how to do so. You will be joining a growing movement of Fort Collins residents, businesses, and community leaders who are helping others create more native habitat in neighborhoods across the city."	Information-based control language: "You may think that you need special training or knowledge to support pollinators around your home, but you already know what to do: Plant a native plant! You can make a difference in your neighborhood! Call a participating nursery to make an order. They can help you find the best plant for your yard. It's easy to get started creating habitat for pollinators. Research finds that people are more likely to do something new when they hear about it from a friend. You don't have to be an expert to reach out to others. You can inspire them no matter if you have planted 1 native plant or 100. When reaching out to others, you can say: 'Planting native plants was new to me, too, but it was simple! I got help at a local nursery, and feel good helping my community provide homes for wildlife. It saves me water. I use fewer fertilizers, and it's beautiful.' When you encourage your friends and neighbors, you are multiplying the benefit to birds, bees, and wildlife in your neighborhood!"

The fourth message condition is a combination of information, efficacy, and norms.

to neighbors, we counted whether or not respondents requested a yard sign as another dependent variable measuring diffusion behavior.

Message Conditions

We randomly assigned participants (with the random number generator in Excel) to receive one of 4 message conditions (control, efficacy, norms, or norms and efficacy) on their mailing (exact language in Table 1, details on message design in Appendix S1). The control message was information only. It discussed the benefits of native plant gardening and encouraged residents to use their self-voucher to purchase a native plant and share their friend-and-neighbor vouchers with others in their social network. This message was meant to provide only basic information about the desired behavior and was thus repeated as a baseline in all other message conditions. The efficacy message built on the control message by providing tips on reaching out to others and persuasive arguments for why reaching out to others made a difference. Our efficacy message built on research by Geiger et al. (2017), who found that providing guidance on what to say when reaching out to others may enhance individuals' willingness to discuss climate change with others by enhancing self-efficacy. Our message also sought to enhance response efficacy by demonstrating why conversations about native plant gardening are likely to have an impact. The norms message built on the control message by providing information about others' behaviors and second-order perceptions related to native plant gardening. Specifically, the normative message shared the results of a prior survey conducted by the research team, which showed that the majority of Fort Collins residents were interested in learning more about native plant gardening and many residents had already planted native plants. The combined norms and efficacy message provided all the information from the previous conditions.

The research was approved by Colorado State University's human subjects institutional review board (protocol 19-8988H).

Analyses

Among our full sample, we examined the effect of the 4 different message conditions on 3 dependent variables: use of a self-voucher at a partnering nursery, a measure of individual-level conservation behavior; use of up to 3 friend-and-neighbor vouchers per mailer recipient at partnering nurseries, a measure of diffusion behavior; and requests for yard signs, another measure of diffusion behavior. We used a binary logistic regression for the first and third dependent variables, given they are binary (yes or no) variables. For our second dependent variable, we intended to use only an ordered logistic regression, given the scale was 0–3. However, few people used 2 ($n = 22$) or 3 ($n = 10$) neighbor vouchers, leading to sparsity when conducting moderation analyses. Thus, in addition to using an ordered logistic regression for our primary outcomes, we ran a binary logistic regression for whether any friend-and-neighbor vouchers were used. For the moderation analyses, we sought to avoid data sparsity by reporting only the binary logistic regression results for whether any friend-and-neighbor vouchers were used. We entered the message condition into the regression as a factor variable and reported the odds ratio of the message condition as the effect size. To include every contrast, we compared each message condition in succession after running regressions.

We ran unadjusted regressions as our primary analysis and regressions adjusted for potential confounders as a sensitivity analysis. In the adjusted analysis, we included prior native plant gardening and diffusion behavior and demographic covariates from the premailing experiment survey. We conducted the adjusted analysis only for the 793 highly involved residents who completed the presurvey because only a small portion ($n = 337$) of the 2000 randomly selected residents completed the presurvey. In adjusted analyses, each potential covariate was prescreened using a bivariate likelihood ratio test with the outcome. If the p value was <0.20, the covariate was included in the model. We prescreened the following covariates obtained from the presurveys: prior engagement in planting of native plants and diffusion of information about native plants, home ownership, gender, age, education, race, and ethnicity (which prior studies show are associated with gardening behavior [Dean et al., 2016; Peterson et al., 2012]). To test whether the message conditions had a different effect on highly involved individuals compared with the random sample, we also conducted the unadjusted analyses above separately for both subgroups.

Our secondary exploratory analyses involved testing which normative and efficacy-based perceptions were most relevant to messaging effects. We conducted a moderation analysis to examine the interaction between the message condition and the presurvey normative and efficacy beliefs on our 3 dependent variables. To conduct the moderation analysis, we added to our regressions an interaction term between the different message conditions and each of the presurvey normative and efficacy beliefs. We conducted a likelihood-ratio test to examine whether adding the interaction terms between these perceptual variables and message condition significantly improved the model fit.

We used the false discovery rate (FDR) method to control for multiple comparisons of treatment arms. Although the FDR may be a conservative estimate in our trial due to dependence between message conditions, it is often used to control for the increased possibility of false positives in trials with multiple treatments and outcomes (MacDonald, 2018). Trials typically report FDR cutoff rates of 0.05–0.25 as significant, depending on whether type 1 and type 2 errors were more problematic within a given study context (MacDonald, 2018). Although an unadjusted p of 0.05 implies that 5% of all tests will result in false positives, an FDR adjusted p of 0.05 implies that 5% of significant tests will result in false positives. Similarly, an FDR adjusted p of 0.25 implies that 25% of significant tests will result in false positives. We report p values with and without the FDR method (with adjusted FDR p-value cutoffs of both 0.05 and 0.25 to discuss significance). When calculating the FDR, we corrected for multiple comparisons within each set of message comparisons separately for each outcome, due to correlated outcomes (Benjamini & Hochberg, 1995).

Results

Sample Characteristics

We obtained presurvey data for all 793 highly engaged residents and 337 of the 2000 residents from the random sample (after dropping responses from 9 participants in the random sample who did not answer over 4 questions). Presurveys indicated that most participants in the highly engaged sample were women (74.3%), white (92.6%), not Latinx (88.1%), older (mean age of 51.6), highly educated (86.2% bachelor's degree or higher); owned their homes (90.4%); and had planted a native plant (87.1%) and tried convince others to plant a native plant (63.0%) before (further descriptive statistics by message condition are in Appendix S2). Similarly, most participants in the random sample who completed the presurvey were women (64.7%), white (93.4%), not Latinx (88.0%), highly educated (84.6% bachelor's degree or higher); owned their homes (80.5%); and had planted a native plant on their properties (68.4%). Half the random sample of participants who completed the presurvey

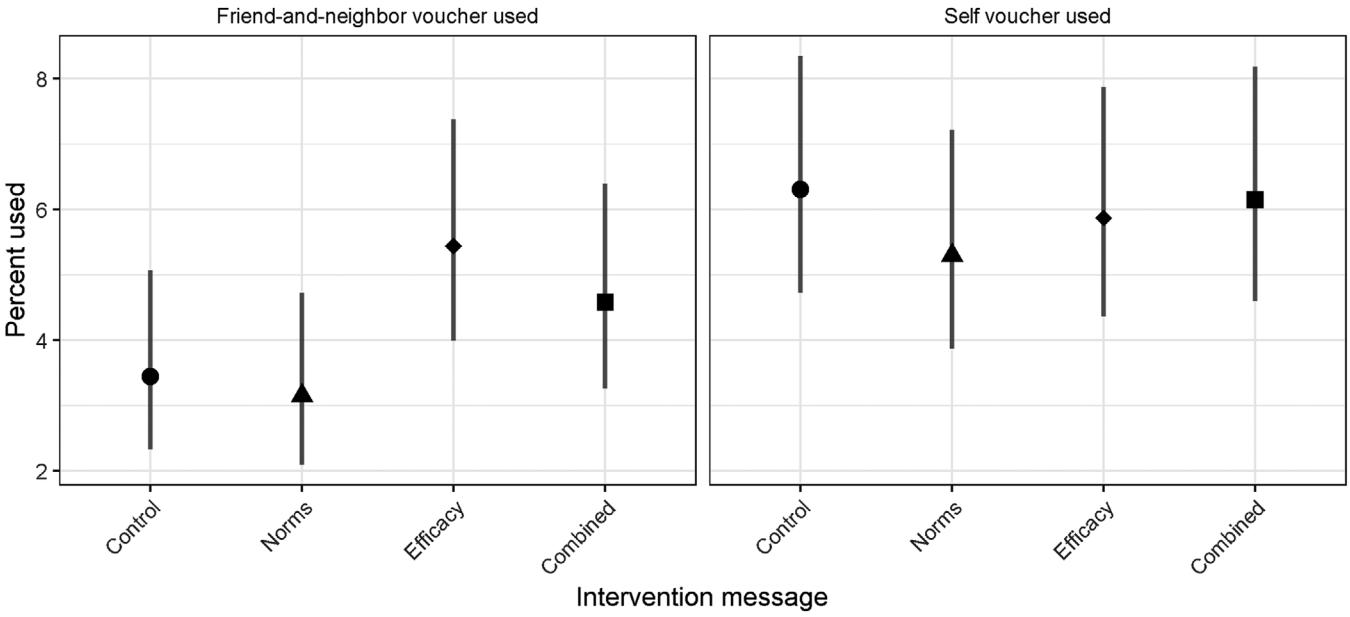

Figure 1. Percentage of self- and friend-and-neighbor vouchers used (mean and CI) to purchase native plants out of the total number of vouchers sent per message condition (x-axis) on mailer cards for the full sample of 2793 residents.

reported having encouraged someone else to plant native plants in the past (50.3%).

Overall Voucher and Yard Sign Use

A total of 165 self-vouchers and 158 friend-and-neighbor vouchers were used among the full sample (i.e., 5.9% of the self-vouchers sent and 1.9% of all friend-and-neighbor vouchers sent). Approximately 62.4% of the self-vouchers ($n = 103$) and 57.0% of friend-and-neighbor vouchers ($n = 90$) used were from the smaller sample ($n = 793$) of highly engaged residents from the Nature in the City mailing list; the remaining (self-vouchers $n = 62$; friend-and-neighbor vouchers $n = 68$) were from the larger sample ($n = 2000$) of randomly chosen residents. Similar voucher use rates were obtained for the 2 different stages of random sample voucher mailings in the Spring (i.e., after the first mailing of 1000 vouchers for the random sample in April, 31 self-vouchers were used and 30 friend-and-neighbor vouchers were used. In the second mailing of 1000 vouchers for the random sample in June, 31 self-vouchers were used and 38 friend-and-neighbor vouchers were used). Of those who had claimed to plant native plants before in presurveys, 13.5% from the highly engaged sample and 13.0% from the random sample used self-vouchers. Of those who indicated they had tried to convince others to plant native plants before in presurveys, 9.8% from the highly engaged sample and 9.9% from the random sample used friend-and-neighbor vouchers. Overall, only 18 yard signs were requested. There were no significant differences among the number of yard signs requested per condition (control = 5, norms = 4, efficacy = 4, and combined = 4).

Message Effects on Voucher Use for the Full Sample

Among the full sample (highly engaged and random combined), there were no significant differences in the number of self-vouchers used between message conditions before and after correcting for FDR (H1 and H2) (Figure 1 & Appendix S2). Overall, for the full sample, the efficacy condition, followed by the combined condition, appeared to lead to the largest number of friend-and-neighbor vouchers used, whereas the norms condition led to the fewest number used (H1 and H2) (Figure 1). However, the significance of these trends varied among different message comparisons and when controlling for FDR. Before correcting for FDR in the binary logistic regressions, the efficacy condition led to a significantly ($p < 0.05$) greater likelihood of friend-and-neighbor voucher use than the normative condition (Table 2 & Figure 1). When controlling for FDR, the difference between efficacy and norms and efficacy and control conditions were significant with an FDR cutoff of 0.25 but not 0.05 (Table 2). Similar results were obtained for the number of friend-and-neighbor vouchers used, modeled using ordinal logistic regression (efficacy compared with norms: odds ratio = 1.77, CI 1.04, 3.02, uncorrected $p = 0.04$; FDR corrected $p = 0.28$; efficacy compared to control: odds ratio = 1.60, CI 0.95, 2.70, uncorrected $p = 0.08$; FDR corrected $p = 0.33$). No other contrasts between message conditions were significantly different in the regression analyses.

Table 2. Results of binary logistic regressions examining the impact of message condition on likelihood of friend-and-neighbor voucher use (an indicator of diffusion).

		Unadjusted for covariates (all samples)				*Adjusted for covariates (highly engaged sample only)*			
Sample	*Message comparison*	*odds ratio*	*confidence interval*	*Uncorrected* p *value*	*false discovery rate corrected* p *value*	*odds ratio*	*confidence interval*	*uncorrected* p *value*	*false discovery rate corrected* p *value*
Full sample ($n = 2793$)	efficacy versus norms	1.769	1.035, 3.024	0.037	0.214				
	efficacy versus control	1.617	0.959, 2.726	0.071	0.214				
	norms versus control	0.914	0.508, 1.646	0.764	0.764				
	combined versus control	1.347	0.785, 2.312	0.279	0.419				
	combined versus norms	1.474	0.848, 2.563	0.169	0.338				
	combined versus efficacy	0.833	0.514, 1.350	0.459	0.550				
Highly engaged sample ($n = 793$)	efficacy versus norms	1.804	0.835, 3.899	0.133	0.399	2.048	0.913, 4.592	0.082	0.246
	efficacy versus control	1.395	0.679, 2.867	0.365	0.548	1.461	0.696, 3.065	0.316	0.475
	norms versus control	0.773	0.342, 1.747	0.536	0.644	0.713	0.306, 1.661	0.434	0.520
	combined versus control	1.551	0.765, 3.144	0.224	0.448	1.662	0.809, 3.415	0.167	0.334
	combined versus norms	2.006	0.940, 4.279	0.072	0.399	2.329	1.059, 5.122	0.035	0.212
	combined versus efficacy	1.111	0.578, 2.138	0.752	0.752	1.138	0.581, 2.228	0.707	0.707
Random sample ($n = 2000$)	efficacy versus norms	1.756	0.827, 3.729	0.143	0.286				
	efficacy versus control	1.936	0.891, 4.205	0.095	0.286				
	norms versus control	1.102	0.464, 2.619	0.826	0.991				
	combined versus control	1.102	0.464, 2.619	0.826	0.991				
	combined versus norms	1.000	0.430, 2.328	1.000	1.000				
	combined versus efficacy	0.569	0.268, 1.209	0.143	0.286				

Message Effects on Voucher Use for the Random and Highly Engaged Subsamples

There were no significant differences in the number of self- and friend-and-neighbor vouchers used between message conditions before and after correcting for multiple comparisons in the subsample of randomly selected residents (H3) (Figure 1 & Appendix S2).

Because all residents in the highly engaged subsample completed the presurveys, we examined the effects of messaging before and after adjusting for covariates for this sample. Before adjusting for covariates among this subsample, there were no significant differences in the number of self- and friend-and-neighbor vouchers used between message conditions either before or after correcting for multiple comparisons (H3) (Figure 1 & Appendix S2). After adjusting for covariates among this subsample, the combined condition appeared to lead to a greater likelihood of a friend-and-neighbor voucher use than the norms condition. This result was significant before controlling for multiple comparisons (Table 2) and after controlling for multiple comparisons at an FDR cutoff of 0.25 but not 0.05 (Table 2). Two covariates were significantly associated with friend-and-neighbor voucher use in the adjusted analysis: whether participants had tried convincing others to plant native plants in the past (odds ratio = 0.49, $p = 0.02$) and gender (specifically, friends-and-neighbor vouchers sent to women were more likely to be used; odds ratio = 0.49, $p = 0.04$). No adjustment covariates were significantly associated with self-voucher use.

Exploratory Moderation Analysis for the Highly Engaged Subsample

Exploratory moderation analyses revealed 2 significant interaction effects among the subsample of highly engaged residents. First, when predicting whether a friend-and-neighbor voucher was used, we found an interaction effect between efficacy and control messages and residents' presurvey perceptions about competence if they communicated with others about native plant gardening (uncorrected interaction $p = 0.01$; FDR corrected $p = 0.08$). The efficacy condition had a stronger positive effect on the likelihood of a friend-and-neighbor voucher being used compared with the control among residents who believed beforehand that others would not perceive them as competent if they were to share information about native plant gardening. When predicting whether a self-voucher was used, we found an interaction effect between the efficacy and control and the combined and control messages and residents' prior perceptions of injunctive norms related to native plant gardening (efficacy vs. control interaction uncorrected $p = 0.03$, FDR corrected $p = 0.09$; combined vs. control interaction uncorrected $p = 0.02$, FDR corrected $p = 0.09$). Specifically, the efficacy and combined messages were more effective than control messages at encouraging self-voucher use among those who had higher prior perceptions of injunctive norms (i.e., believed others would support their efforts to plant native plants). Among those with lower prior perceptions of positive injunctive norms, the control messages were more effective.

Discussion

We hypothesized that normative, efficacy-based, and combined normative and efficacy-based messages would lead to more indicators of individual and diffusion behavior than the control (information only) messages, particularly for the random sample. Instead, we found efficacy messages increased residents' willingness to communicate with others (as indicated by friend-and-neighbor voucher use) compared with normative messages among the full sample. The combined normative and efficacy messages increased residents' willingness to communicate with others compared with the normative messages among the highly engaged sample of residents. However, our estimates were generally significant at a 0.25 but not a 0.05 FDR cutoff (meaning that <25% of significant results would be false positives but not <5%). We compared these cutoff rates because they covered the full range of possible cutoffs discussed in MacDonald (2018). Given these results, we believe our findings should be interpreted as initial evidence of the impact of efficacy messaging.

Our hypothesis that normative or efficacy messages would be particularly effective for the random sample compared with the highly engaged sample was not supported. The elaboration likelihood model of persuasion suggests that messaging, such as normative interventions, may have a greater impact on individuals who are less involved with an issue (Petty & Cacioppo, 1986; Schultz et al., 2016) because those who are more involved are likely already compelled to enact the behavior through intrinsic motivation. However, there were no significant differences between voucher use among messaging conditions in our random sample. Rather, we found differences in voucher use between messaging conditions after adjusting for covariates in the highly engaged sample. In this sample, the combined norms and efficacy message was more effective than the norms message after adjusting for covariates. We see several potential explanations for the significant differences in messaging effects for the highly engaged sample but not the random sample. First, we adjusted for covariates in the highly engaged sample, whereas we could not for the random sample. The significant differences in message conditions in the highly engaged sample emerged only after adjusting for covariates. Additionally, results of our comparison of demographics and past behavior

among both samples suggested that those responding to presurveys and using vouchers from the random sample had engaged in similar numbers of past behaviors and had similar demographics as those in the highly engaged sample. This provides evidence that our messaging did not motivate less engaged individuals and led to the same types of residents engaging from both samples. However, fewer total residents used vouchers from the random sample, meaning we may have lacked the power to detect differences between message conditions for this subsample. Further research is needed on whether involvement with a conservation issue moderates the impact of messaging on behavioral outcomes.

Our findings regarding the overall ineffectiveness of the norms-only message are contrary to findings from recent studies that show sharing information about the large number of others engaging (or starting to engage) in a behavior can enhance conservation action (Geiger & Swim, 2016; Kusmanoff et al., 2020; Sparkman & Walton, 2017). However, several randomized control trials applying normative messaging to biodiversity conservation show null or even negative impacts of social norm interventions (Byerly et al., 2019; Niemiec et al., 2020*b*). Byerly et al. (2019), for example, found that providing information to maple producers about the participation of others in a bird habitat conservation program had a negative effect on the number of producers requesting information about the program compared to an information-only control. Their explanations for the negative impact of normative messaging include the potential for psychological reactance (producers felt their sense of autonomy was threatened by the social norms message) leading to a defensive response. They also suggest that the broad descriptive normative information in the message conflicted with the more common nonparticipation norm in recipients' immediate social network.

Similarly, Niemiec et al. (2020*b*) found that while sharing descriptive norms about the number of Coloradans who support wolf restoration in the state changed perceptions of descriptive norms, the altered normative perceptions did not change behavioral intentions to vote for or share information in support of wolf restoration. They suggest this was because the normative information provided regarded too broad a reference group (i.e., all of Colorado) to be influential and people may instead be more affected by normative information related to their specific social groups, especially for such a controversial topic. The literature on self-categorization (Turner et al., 1987) and social identity theory (Tajfel et al., 1979) suggests that people are most motivated to emulate others that they perceive as prototypical of social groups they identify with.

These same explanations may apply to our sample of residents. It is possible residents may not have believed the normative information in the message, particularly if a lack of native plant gardening by their neighbors created conflict between local perceived descriptive and dynamic norms and the norms that were shared in our message. People may develop normative perceptions about native plant gardening through interactions with others in their community and visual observations of others' lawns (Locke et al., 2018); thus, these perceptions may be difficult to alter through one-off messaging. Future research is needed on how normative messaging interacts with people's immediate social context and whether normative messaging focused on more specific social groups (e.g., people's immediate neighbors) effectively influences conservation behaviors.

Efficacy messages tended to be particularly effective at encouraging diffusion among a subset of highly engaged residents who believed, in presurveys, that others would not see them as competent if they communicated about native plant gardening. These findings are consistent with work by Geiger and Swim (2016), who found that participants' willingness to discuss climate change is mediated by their beliefs of how competent they would be perceived in a conversation about climate change. Similarly, Jones and Niemiec (2020) found that perceived competence in approaching others was a predictor of past diffusion behavior related to native plant gardening. These results highlight the importance of building people's feelings of competency in communicating with others in outreach and behavioral change programs. Interventions designed to guide individuals on how to most effectively communicate with others about conservation causes could build these feelings of competency.

We also found some evidence of an interaction effect between highly engaged residents' prior perceptions of injunctive norms, efficacy and combined conditions, and their use of self-vouchers. Residents who believed others would be supportive of their efforts to plant native plants were slightly more likely to use a self-voucher when they received the efficacy or combined efficacy and normative messages compared with the control. This suggests residents need to feel a baseline level of social support before an efficacy message is motivating, possibly because a perceived lack of social support is a key barrier preventing behavior change even when other barriers are removed. Normative messages on mailers alone did not effectively remove this normative barrier and change behavior. Thus, research is needed on other types of interventions that will increase people's perceptions of supportive injunctive norms.

Although we used real-world indicators of conservation behavior, the type of indicators we applied introduced some limitations. For example, it is possible that people may have been motivated to plant native plants by our messaging but may not have specifically used the vouchers we gave them. In emails to our survey team, some residents reported wanting to buy plants from locations other than where they could redeem vouchers. Participants could have been inspired to share information

about native plant gardening based on the messaging, but their sharing of information may not have effectively motivated others to use the friend-and-neighbor vouchers.

A key limitation of our study is that messaging was delivered by mail, and we were unable to determine how many respondents actually viewed our mail. If a significant portion of residents did not view their mail, this could have reduced the power of our study and led to nonresponse bias. To address the possibility of low power, we included approximately 700 people per message condition in our full sample (when our power analysis indicated only 200 per condition was needed to detect 0.2 SD change between conditions with an alpha of 0.05). To increase mail-opening rates, we sent out reminder postcards with drawings of native plants and a clear postmark from the local city government. Despite these efforts, overall voucher use was low (5.91% for self-vouchers and 1.89% of all friend-and-neighbor vouchers), which may have limited the strength of our conclusions. Larger sample sizes, additional measures to increase recipient engagement with messaging, and tracking how many respondents actually view the delivered messages are needed.

Another limitation of our study is that we combined multiple types of efficacy messages and normative messages. For example, our efficacy message sought to increase communication with others and planting of native plants on one's own property. Thus, we could not distinguish which aspect of the efficacy messages were most motivating. Further, our messages focused only on 2 potential psychological barriers and were designed primarily based on theory and prior field experiments. Additional barriers and motivations influencing residents' willingness to engage in diffusion behavior for conservation causes need further investigation. Not personally identifying as an activist, for example, prevents people from engaging in more collective actions to address climate change (Roser-Renouff et al., 2014)—social identity may be an important variable we did not consider.

Because we implemented this experiment during COVID-19, the extent to which our findings apply to other populations and other periods is uncertain. Presurveys revealed that our highly engaged sample (and the proportion of our random sample who answered the presurvey) was mostly white, older, highly educated women, and homeowners. It is unclear whether messaging may differentially affect other audiences. Furthermore, although mailing minimized COVID-19 disease transmission, the pandemic may have changed participants' gardening and socializing interests in various ways that could have affected voucher use.

Whether greater effects on efficacy, normative perceptions, and associated behavior can be created through in-person and online workshops and community events needs investigation. In a meta-analysis of experimental studies on conservation behavior change, social influence approaches that use face-to-face interaction tend to have larger effective sizes on behavior than interventions that involve unidirectional messaging (Abrahamse & Steg, 2013). Perhaps hands-on efficacy-building interventions (e.g., giving residents practice engaging in diffusion behaviors [Bandura, 1998]) and hands-on norm-building interventions (e.g., having residents share their collective experiences and develop new normative expectations together [Niemiec et al., 2019]) may be more effective than one-off written messaging.

The limitations and opportunities of the block leader approach for biodiversity conservation should also be investigated. Questions include is this approach as effective for conservation issues as other proenvironmental issues (e.g., recycling) and how might characteristics of the block leaders affect their effectiveness at diffusing new behaviors? Climate actors who employ diffusion behavior may be perceived as less credible, and may therefore be less effective at motivating others, when their lifestyles are seen as unusually sustainable (Sparkman & Attari, 2020). Building on social identity theory (Tajfel et al, 1979) and self-categorization theory (Turner et al., 1987), are block leaders who are seen as more prototypical of social groups more effective at encouraging others in their social groups to change their behavior? How does the network of block leaders affect their effectiveness at diffusing information? For example, are some block leaders with strong environmental values positioned to make less of an impact because they are embedded in networks of individuals with similar beliefs?

Our study builds on the growing body of research examining how to facilitate the diffusion of conservation behavior through social networks. Our results provide preliminary evidence that efficacy-based and combined efficacy and normative messaging may be more effective than normative messaging at encouraging the diffusion of conservation behavior. However, these results are preliminary, given that they were only significant before correcting for FDR and after correcting for FDR with a cutoff of 0.25 but not 0.05. Our study highlights the need for future research on how efficacy-building outreach interventions can encourage residents to diffuse conservation behavior throughout their networks, to ultimately scale up conservation across societies.

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Supporting Information

Additional information is available online in the Supporting Information section at the end of the online article. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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